Additional Resources for Chapter **One**

The materials below pertain to the behavioral questionnaire mentioned in Chapter 1, and to discussion of some deeper issues associated with heuristics, biases, and prospect theory.

A1.1 QUESTIONNAIRE

This section provides a set of questions which pertain to psychological concepts discussed in Chapter 1.[1] Please record your answers in the Excel file *Chapter 1 Questionnaire Answer Template.xlsx* that can be downloaded from the book web site.

1. Below you will find a list of 18 possible events that might happen to you during your lifetime. Examine the events and answer the questions that appear below.

1. Being fired from a job
2. Your work recognized with an award
3. Having gum problems
4. Living past age 90
5. Having a heart attack
6. Tripping and breaking a bone
7. Being sued by someone
8. No night spent in hospital for 5 years
9. Victim of mugging
10. Decayed tooth extracted
11. Your achievements in newspaper
12. Body weight constant for 10 years
13. Having your car stolen
14. Injured in auto accident
15. In 10 years, earnings greater than $2 million a year
16. Developing cancer
17. Not ill all winter
18. Deciding you chose wrong career

Please answer the following question: Compared to other people in this class—same sex as you—what do you think are the chances that the events described above will happen to you in the future? The choices range from much less than average, to average, to much more than average. **Note: Enter the number to the left of the category as your answer, not the category itself.** *For example, if your answer is 60% less, record*

"3" as your answer, not "60% less." For some of you, these events might have already happened to you in the past. If so, simply answer the question in terms of the events happening to you again in the future. The categories from which you choose are as follows:

1. 100% less (no chance)
2. 80% less
3. 60% less
4. 40% less
5. 20% less
6. 10% less
7. average
8. 10% more
9. 20% more
10. 40% more
11. 60% more
12. 80% more
13. 100% more
14. 3 times average
15. 5 times average

2. Below you will find a trivia test consisting of ten questions for you to answer **from memory alone.** In addition to giving your best guess, consider a range: a low guess and a high guess so that you feel 90 percent confident that the right answer will lie between your low guess and your high guess. Try not to make the range between your low guess and high guess too narrow. Otherwise, you will appear overconfident. At the same time, try not to make the range between your low guess and high guess too wide. This will make you appear underconfident. If you are well calibrated, you should expect that only one out of the ten correct answers does not lie between your low guess and your high guess.[2]

After each question, write down three numbers—your best guess, low guess, and high guess. *Do not add words such as miles, etc. to your answer.*

1. How old was Martin Luther King, Jr. when he died?
2. How long, in miles, is the Nile River?
3. How many countries were members of OPEC in 1989?
4. According to the conventional canon, how many books are there in the Hebrew Bible?
5. What is the diameter, in miles, of the moon?
6. What is the weight, in pounds, of an empty Boeing 747?
7. In what year was Wolfgang Amadeus Mozart born?
8. How long, in days, is the gestation period of an Asian elephant?
9. What is the air distance, in miles, from London to Tokyo?
10. How deep, in feet, is the deepest known point in the ocean?

3. Relative to all the people in the class, how would you rate yourself as a driver? (1) Above average? (2) Average? (3) Below average? Here average is defined as the median. **Enter a number (1, 2, or 3) in the Excel answer template.**

4. Imagine that you are presented with four cards placed flat on a table in front of you. There is a letter on one side of the card and a number on the other side of the card. You see the following on the four cards: **a, b, 2,** and **3**.

a	b	2	3

Suppose you are asked to test the following hypothesis about *these* four cards: "Any card having a vowel on one side has an even number on the other side." Imagine that you are asked to select those cards, and only those cards, that will determine whether the hypothesis is true. That is, please select the minimum number of cards that will enable you to determine whether or not the hypothesis is true. Of the four cards, which would you turn over to verify the hypothesis? **Indicate your choices by placing a 1 beside your choices, and a 0 otherwise.**

5. Imagine that you hear about a 31-year-old woman named Linda, from people who know her quite well. They tell you that she is single, outspoken, and very bright. When she was a student, she was deeply concerned with issues of social justice. Linda's friends neglect to tell you about her current interests and career. Consider the following eight choices.

1. Linda is a teacher in an elementary school.
2. Linda manages a bookstore, and takes yoga classes.
3. Linda is active in the women's movement.
4. Linda is a psychiatric social worker.
5. Linda is a member of the League of Women Voters.
6. Linda is a bank teller.
7. Linda is an insurance salesperson.
8. Linda is a bank teller, and is active in the women's movement.

Rank these possibilities about Linda from 1 to 8 by assigning 1 to what you regard as the most likely possibility, and 8 to what you regard as the least likely possibility.

6. Please answer the following three questions:

6.1 Record the last three digits of your primary phone number.

6.2 Add 400 to the last three digits of your home phone number. Call the sum X. Without looking up the answer anywhere, do you think that Attila the Hun was defeated in Europe before or after the year X? (Before = 1, After = 2)

6.3 Without looking up the answer anywhere, provide your best guess about the actual year that Attila the Hun was defeated in Europe.

7. This question has three parts, 7.1, 7.2, and 7.3. However, you will answer either 7.2 or 7.3, depending on your answer to 7.1.

7.1 Is the date of your birthday an even number or an odd number? (For example, if your birthday falls on January 2, enter a 0 for even. Enter a 1 for odd.)

If the date of your birthday is an even number, answer question 7.2. If the date of your birthday is an odd number skip to question 7.3.

7.2 Imagine that you are offered the opportunity to participate in a baseball pool. The pool works as follows. Imagine that in front of you lies a pile of 227 baseball cards, with the face of each card displaying the picture of a *different* baseball player. Indeed, imagine that there are two identical piles in front of you, each containing 227 baseball cards. The organizer of the pool asks you to look through one pile, select one card, and show it to him. After you have done so, the organizer looks through the second (duplicate) pile, finds the twin of the card you selected, and deposits the twin into a brown cardboard carton. In order to participate, you pay $1 to a pool organizer for each card you select. After all the cards have been sold, there will be 227 cards in the organizer's carton, of which one will be yours. The organizer will then draw exactly one card from the carton. The owner of the winning card receives a $50 prize.

Suppose that all the cards have been sold, but the drawing has yet to take place.

The pool organizer approaches you to say that someone who really wanted to participate cannot, because all the cards have been sold. He asks you how much you would be willing to accept in exchange for the card you drew. What is the *minimum* amount you would ask for to give up your card?

7.3 If the date of your birthday is an odd number answer the following question. If the date of your birthday is an even number you should have answered question 7.2 and should also skip this section and continue with question 8.

Imagine that you are offered the opportunity to participate in a baseball pool. The pool works as follows. Imagine that in front of you lies a pile of 227 baseball cards, with the face of each card displaying the picture of a *different* baseball player. Indeed, imagine that there are two identical piles in front of you, each containing 227 baseball cards. The organizer of the pool has flipped through one pile, selected one card, and given it to you. After having done so, the organizer looks through the second (duplicate) pile, finds the twin of the card she selected, and deposits the twin into a brown cardboard carton. In order to participate, you pay $1 to a pool organizer for the card you select. After all the cards have been sold, there will be 227 cards in the organizer's carton, of which one will be yours. The organizer will then draw exactly one card from the carton. The owner of the winning card receives a $50 prize.

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8. Suppose that a university is attempting to predict the grade point average (GPA) of some graduating students based on their high school GPA levels. As usual, a student's GPA lies between 0 and 4. Below are some data for undergraduates at Santa Clara University, based on students who entered the university in the past.[3] Historically, the mean high school GPA of students who entered as freshmen and graduated was 3.44 (standard deviation was 0.36). The mean college GPA of those same students was 3.08 (standard deviation 0.40). Suppose that it is your task to predict the college GPA scores of 3 graduating students, based solely on their high school GPA scores. The 3 high school GPAs are 2.2, 3.0, and 3.8. Write down your prediction below for the college GPAs of these students upon graduation, and enter them into the Excel answer template recording your answers.

Prediction of graduation GPA of student with high school GPA of 2.2 = ______
Prediction of graduation GPA of student with high school GPA of 3.0 = ______
Prediction of graduation GPA of student with high school GPA of 3.8 = ______

9. Imagine that you have an opportunity to win $10 by randomly drawing a white bean from one of two jars, denoted Jar 1 and Jar 2. Jar 1 contains 10 beans, of which one is white and the rest are black. Jar 2 contains 100 beans, of which 7 are white and the rest are black. You can choose the jar from which the drawing will take place. Which jar would you choose, Jar 1 or Jar 2?

10. Question 1 pertains to a series of possible life events. Please assess each of these events on the following criteria:

A. For each of the life events, assign one of the following controllability category numbers (1 through 5):

1. There is nothing one can do that will change the likelihood that the event will take place.
2. There are things one can do to have a small effect on the chances that the event will occur.
3. There are things one can do to have a moderate effect on the chances that the event will occur.
4. There are things one can do to have a large effect on the chances that the event will occur.
5. The event is completely controllable.

B. For each of the life events, assign a desirability number on a scale of 1 to 9, which can be odd or even, where

- 1 = extremely undesirable
- 3 = undesirable
- 5 = neutral
- 7 = desirable
- 9 = extremely desirable

C. For each of the life events, assign a category number for familiarity, where the categories are:

1. The event has not happened to anyone I know.
2. The event has happened to acquaintances.
3. The event has happened to friends or close relatives.
4. The event happened to me once.
5. The event has happened to me more than once.

D. For each of the life events, assign a category number to indicate the degree to which you believe the event will happen to you:

1. Impossible to not likely
2. Very low chance
3. Doubtful
4. A small chance
5. Possible
6. There is a chance
7. Reasonable chance
8. Most likely
9. High chance
10. Very high chance to certain

E. In respect to the likelihood that each of the life events apply to you, which category do you think is most appropriate? Enter the number of the category.

1. Impossible to not likely
2. Very low chance
3. Doubtful
4. A small chance
5. Possible
6. There is a chance
7. Reasonable chance
8. Most likely
9. High chance
10. Very high chance to certain

11. Imagine that you are given the opportunity to play a 50–50 risky alternative whose outcome will be determined by the toss of a coin. If the coin toss comes up tails, you lose $500. If the coin toss comes up heads, you win $5,000. You can choose to accept the risky alternative, or you can choose to reject the risky alternative.

11.1 Would you accept or reject the 50–50 risky alternative where you either lose $500 or win $5,000? (Accept = 1, Reject = 0)

11.2 Imagine a 50–50 risky alternative where you lose $500 if the coin toss comes up tails, but win a different amount if the coin toss comes up heads. What is the lowest amount you would have to win in this risky alternative and yet still accept the risk? For example, if you accepted the 50–50 risky alternative between winning $5,000 and losing $500, would you still be willing to accept if the risky alternative was between winning $2,500 and losing $500? If you answer yes, would you still be willing to accept if the risky alternative was between winning $1,250 and losing $500? In other words, think about how low your win would have to be before you were indifferent between accepting and rejecting the opportunity to face the risky alternative. Enter the lowest acceptable winning amount in your Excel answer template.

12. Consider the danger of death or injury stemming from four sources, all involving water:

1. shark attacks
2. hurricanes
3. riptides
4. floods

Which item in the above list involves the most danger to people? (Note: Enter the number of the item.)

13. Suppose that you face a choice between two risks. Which of the two would you choose?

A. 90 percent chance of winning $2,000
   10 percent chance of zero. $0

B. 45 percent chance of winning $4,000
   55 percent chance of zero. $0

14. Suppose that you face a choice between two risks. Which of the two would you choose?

C. $2,000 with probability .002
   0 with probability .998

D. $4,000 with probability .001
   0 with probability .999

15. Suppose that you face a choice between two risks. Which of the two would you choose?

E. 90 percent chance of losing $2,000
   10% chance of losing $0

F. 45 percent chance of losing $4,000
   55 percent chance of losing $0

16. Suppose that you face a choice between two risks. Which of the two would you choose?

G. lose $2,000 with probability .002
   lose $0 with probability .998

H. lose $4,000 with probability .001
   lose $0 with probability .999

17. Suppose you had an opportunity to take a risk with a 25 percent chance of winning $7,500, and a 75 percent chance of losing $2,500. Would you be willing to take this chance? Yes or no?

18. Suppose you face an unavoidable situation where there is a 75 percent chance you will lose $7,600 and a 25 percent chance you will win $2,400. However, imagine that before you learn the outcome of this gamble, you are offered a certain $100, no strings attached. If you accept the $100 and lose, your net loss will be $7,500 instead of $7,600. If you accept the $100 and win, your net gain will be $2,500 instead of $2,400. Accepting the $100 does not mean that you can avoid facing the risk. What accepting the $100 does is to reduce your loss by $100 in the event that you lose, and increase your gain in the event that you win. Would you accept the $100? Yes or no?

19. Imagine that you face the following pair of *concurrent* decisions. Think of making your choices in the morning, with the outcome to the first decision being determined in the afternoon, and the outcome of the second decision being determined in the evening. Imagine that the current time is morning. First examine both decisions, and then indicate the option you prefer.

First decision: Choose between

I. a sure gain of $2,400

J. 25 percent chance to gain $10,000 and 75 percent chance to gain nothing.

Second decision: Choose between

K. a sure loss of $7,500

L. 75 percent chance to lose $10,000 and 25 percent chance to lose nothing.

Indicate your choices by placing a 1 beside your choices in the Excel answer template, and a 0 otherwise.

20. Consider a geographic area that is served by two taxi companies, one large and the other small. Eighty-five (85) percent of the taxis are operated by the larger company, which uses yellow cabs. The smaller company uses red cabs. Suppose that there is a hit-and-run accident involving a taxi one evening, and an eye witness reports that the taxi was red. In testing the accuracy of the eye witness, the police determine that in circumstances similar to those in which the accident occurred, the witness correctly identifies the color of the taxi 80 percent of the time.

Answer the following two questions about the hit-and-run accident.

a. Taking into account the eye witness report, what probability would you assign to the color of the taxi involved in the accident truly being red?

b. In addition to giving your best probability estimate, specify a low estimate and a high estimate so that you feel 90 percent confident that the right answer will lie between your low estimate and your high estimate.

A1.2 REPRESENTATIVENESS AND BAYES' RULE

The main point of the "Linda problem" discussed in the chapter is to point out that relying on heuristics can make people vulnerable to fallacious judgments such as succumbing to the conjunction fallacy. In the Linda problem, the heuristic in question is based on representativeness, the overreliance on stereotypes.

To sharpen the discussion of representativeness, consider the application of a representativeness-based heuristic for the Linda problem when expressed in a System 2 framework. In this respect, System 2 thinking is deliberative and

EXHIBIT A1-1 **A Formal Heuristic Approach to Rank Ordering the Eight Possible Fields in the "Linda Question"**

	Single	Outspoken	Very Bright	Social justice	Total	Rank
Elementary school teacher	5	4	4	5	18	7
Manages a bookstore, takes yoga	6	7	8	8	29	2
Active in women's movement	8	8	8	10	34	1
Psychiatric social worker	5	5	9	8	27	4
Member League of Women Voters	5	7	7	9	28	3
Bank teller	5	3	3	3	14	8
Insurance salesperson	6	4	5	4	19	6
Bank teller, active in women's movement	5	8	3	10	26	5

conscious. Exhibit A1-1 displays a table illustrating a formal heuristic approach to rank ordering the eight possible fields in the Linda question. The rows in the table correspond to the eight fields, and the columns correspond to the four traits ascribed to Linda in the question. Each field is assigned four scores, with each score being a whole number between 1 and 10. The four scores are tallied up to yield a total score for each field, and are displayed in the second column from the right. These totals provide the basis for a rank ordering, which is displayed in the column at the extreme right.

Notice that with these illustrative scores, "active in the women's movement" has the highest rank, and "bank teller" has the lowest rank. Being a bank teller who is active in the women's movement ranks number 5. These rankings are in fact typical of how people respond to the diagnostic question in practice; and of course, they result in judgments that exhibit the conjunction fallacy.

The point of this example is not that people build tables such as Exhibit 1-7 to answer the Linda problem. In fact, hardly any do. The point is that people rely on intuitive thinking to make judgments in situations such as the Linda problem. That is, they match the various field stereotypes in their minds against the picture of Linda they hold, based on her characteristics: the closer the match—meaning the more representative is Linda of the field—the higher the rank.

System 2 thinking takes time and effort, both of which are scarce. There is no good reason to engage in System 2 thinking if System 1 can get the job done just as well. Indeed, it might well be the case that succumbing to the conjunction fallacy is a small price to pay for what is ostensibly a reasonably effective heuristic which works well in most cases.

At the same time, the above discussion makes clear that even using System 2, as is the case with Exhibit A1-1, does not prevent susceptibility to bias. Some System 2 thinking is better than others. In this regard, psychologists point out what most people do not do, as well as what they actually do. What they do not do is to use techniques such as Bayes' rule, even when they learned such techniques while studying probability and statistics.

Consider how we might use a textbook probability analysis to think about the Linda problem. Let the symbol "F" denote field and the symbol "D" denote the description of Linda. With this notation, let P(F) be the probability associated with a field, which we interpret as the proportion of people who belong to field F, out of all people working in the eight fields. If we had absolutely no information about Linda, neither name nor gender, and our task was to attach a probability to this person being in field F, then the sensible thing to do would be to use P(F).

Of course, the question provides us with a description of Linda, which we denote by D. So now our task to attach a probability to Linda being in field F is to arrive at the conditional probability P(F|D). According to **Bayes' rule,** one of the basic equations of probability,

$$P(F|D) = P(F)\ P(D|F)/P(D)$$

This equation stipulates that the conditional probability that Linda belongs to field F, given her description, can be obtained by multiplying the unconditional probability by a likelihood ratio. The likelihood ratio P(D|F)/P(D) divides the proportion of people in field F who conform to Linda's description by the proportion of all people in the sample who share Linda's description. For example, suppose that 25 percent of the people in our sample are bank tellers, and that among bank tellers 15 percent conform to Linda's description. Furthermore, suppose that 30 percent of the people in our sample conform to the description of Linda. In this case,

$$P(F = \text{bank teller} \mid \text{Description of Linda}) = 0.25 \times 0.15/0.3 = 0.125$$

If we had no description of Linda available, then the probability we would attach to Linda being a bank teller in this example would be 25 percent, as 25 percent of our sample consists of bank tellers. However, with the description of Linda available, we can adjust the 25 percent. In this case we multiply the 25 percent by a half, because while 30 percent of our sample shares Linda's description, only 15 percent of bank tellers share Linda's description.

Moreover, by working directly with probabilities, we avoid the conjunction fallacy. The probability associated with bank tellers who are active in the women's movement will be less than or equal to the probability associated with bank tellers, regardless of whether we confine ourselves only to people who share Linda's description or to all people in the sample.

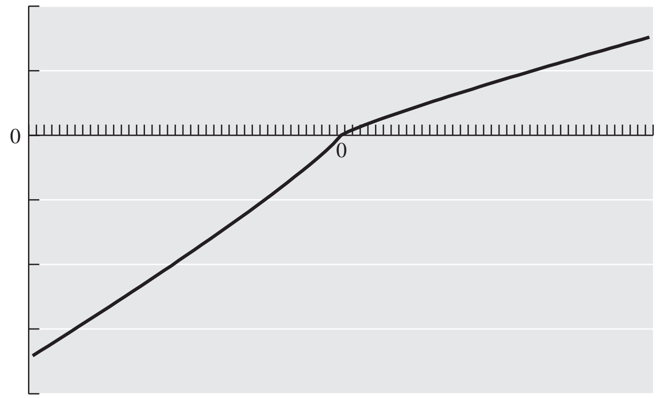
Although applying Bayes' rule is not complicated, it also is not intuitive. In other words, it is a System 2 activity, not a System 1 activity. That is why most people do not use it in the course of making everyday judgments in their lives.

A1.3 FORMAL STRUCTURE OF PROSPECT THEORY

Framing effects are complicated, and our vulnerability to them is best explained in the context of a formal framework. The framework in question is called *prospect theory,* which is a formal model consisting of three basic components: a value function, a weighting function, and an editing structure.[4]

The value function is displayed in Exhibit A1-2. The argument of the function is a gain or loss, with positive arguments denoting gains and negative arguments

EXHIBIT A1-2
The Value Function in Prospect Theory



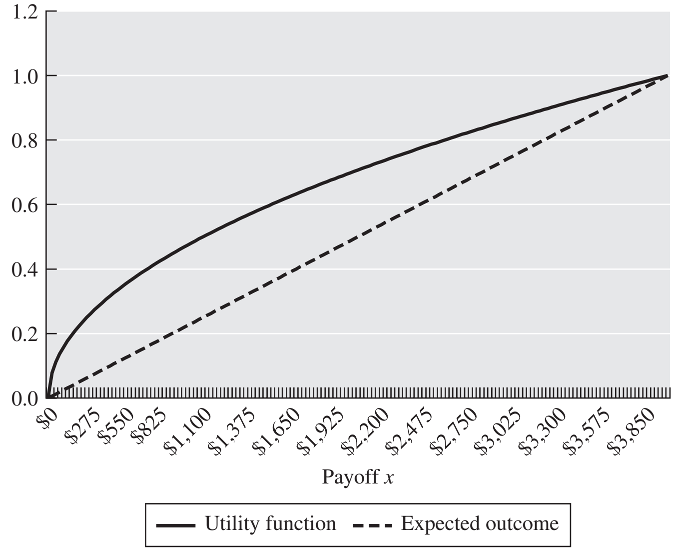
denoting losses. Gains and losses are defined as differences from a specified **reference point** so that gains are positive carriers of value and losses are negative carriers of value. Notice that the value function is zero at the origin, and is S-shaped, being concave in the domain of gains, convex in the domain of losses, and more steeply sloped at the origin for losses than for gains. The interpretation of the value function is that gains and losses are the psychological carriers of value, with value being higher for lower losses and higher gains. As discussed below, prospect theory holds that people make choices among alternative risks by forming weighted averages of values, akin to the computation of expected value, and with the chosen alternative featuring the highest weighted average.

The shape of the value function captures a set of important properties. The value function is more steeply sloped at the origin when viewed from the left than from the right. This feature captures the concept of loss aversion. The value function is concave in the domain of gains, and convex in the domain of losses. This feature underlies the first two patterns of the fourfold pattern property, where the probability associated with nonzero outcomes is moderate in magnitude, in which people behave as if they are risk averse in the domain of gains and risk seeking in the domain of losses.

The concave shape of the value function in the domain of gain and convex shape in the domain of losses reflects a psychological property known as "psychophysics." Economists employ a notion similar to psychophysics which they call "diminishing returns." The idea is that successive unit increases in a stimulus, such as a gain or a loss, produce marginal responses that decline with the size of the stimulus. In other words, starting at zero, the first unit gain generates the most impact, and the magnitudes of the impacts associated with successive gains are decreasing. Similarly, the first unit loss has associated with the largest impact (in absolute value), and successive losses are less impactful at the margin.

To see the relationship between concavity and risk aversion, examine Exhibit A1-3, showing the portion of the value function associated with gains. Here the degree of

EXHIBIT A1-3
Utility Functions



concavity is exaggerated for illustrative purposes. Consider a risk which features a 60 percent probability of winning $4,000 and a 40 percent probability of winning $0. Notice that in Exhibit A1-3, the value attached to no gain is 0 and the value attached to winning $4,000 is 1. The expected gain from taking this risk is $2,400, and the expected "value" (associated with the value) function is 0.6, which lies along the straight line in the figure.

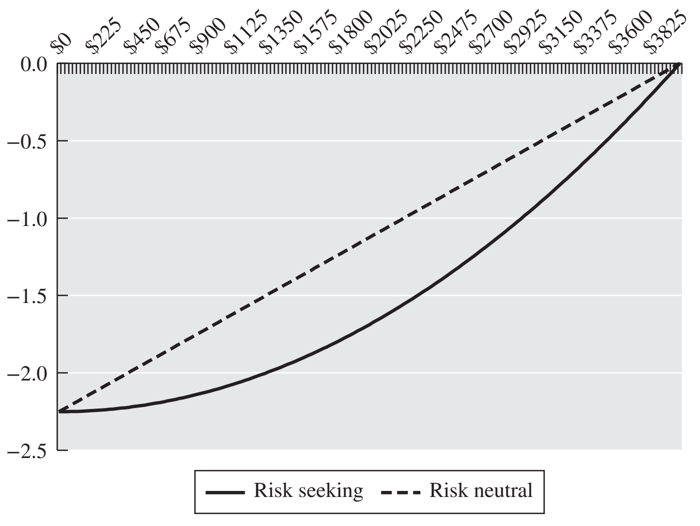
Because the value function is concave in the domain of gains, the value associated with a certain $2,400 gain is more than 0.6. Specifically, it is 0.81. If the weights used to compute the weighted average of possible values were probabilities, and the person were being asked to choose between accepting the risk (with its associated expected value of 0.6) and a sure gain of $2,400 (with its associated value of 0.81), the choice would be to accept the sure gain. In fact, even if the sure gain were somewhat less than $2,400, the sure gain would be the favored choice. In this example, a sure gain as low as $1,450 would still be considered a better choice than facing the risk.

A decision maker who would choose the risk if the sure gain were below $1,450 is effectively asking for a risk premium of $950, the difference between the expected $2,400 and the certain $1,450. In this case, the $1,450 is called the decision maker's "certainty equivalent." Per dollar of the certainty equivalent, the decision maker is effectively requiring a 65 percent premium as compensation for accepting the risk.

A risk premium this high stems from the high curvature of the value function. Were the value function less concave in gains, the risk premium would be lower. In fact, were the value function linear, meaning no curvature, the risk premium would be zero.

On the flip side, consider what happens in the case of a loss. Exhibit A1-4 displays the portion of the value function associated with losses. The degree of

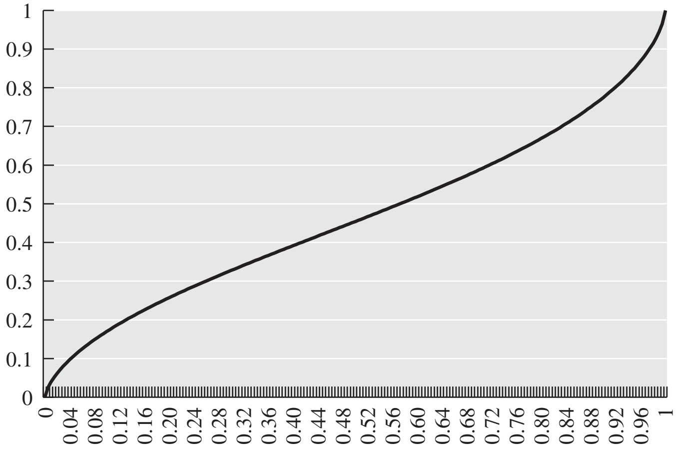
EXHIBIT A1-4
Portion of the Value Function Associated with Losses



convexity is exaggerated for illustrative purposes. Imagine a risk that is identical to the one described just above except that the outcomes are losses rather than gains. In this case, because the value function is convex rather than concave, the decision maker would choose the risk over a sure $2,400 loss. Now the sure loss would have to be $3,100 or more for the decision maker to choose a sure loss over the risk.

Prospect theory's second component is the weighting function. This function is depicted in Exhibit A1-5 and has the shape of an inverse S. In prospect theory, actual probabilities such as the 60 percent and 40 percent used in this example are not actually used to compute expected value. Instead, probabilities are transformed using the weighting function displayed in Exhibit A1-5. The transformation is used to reflect the patterns in the fourfold pattern associated with low probabilities.

EXHIBIT A1-5
Prospect Theory's Weighting Function



Transformed probabilities are called "decision weights." For example, for the case of a risk involving a 60 percent probability of a $4,000 gain and 40 percent probability of a $0 gain, the decision weight attached to the 60 percent probability implied by the graph in Exhibit A1-5 is 0.52. The weighting function is actually applied to the probability of the gain being *at least* $4,000, and since the maximum gain is $4,000, the probability of the event in question is 60 percent. The probability that the gain will be at least zero in this example is 100 percent, which has a decision weight of 100 percent. The decision weights are then computed as differences, namely 52 percent and 48 percent, where 48 percent is the difference, $0.48 = 1 - 0.52$.

A similar procedure applies when the risky alternative relates only to losses, with the computation of the decision weights beginning with the maximum loss, just as the computation for gains began with the maximum gain.[5] Technically, the focus on gains or losses being at least a particular amount means that the argument of the weighting function involves cumulative probabilities in the case of losses and decumulative probabilities in the case of gains.

For risks that feature a mix of gains and losses, the decision weights are first computed for gains, keeping in mind that the probability that the outcome will feature a gain that is at least zero now being less than 100 percent. Next the decision weights are computed for losses. Exhibit A1-6 illustrates the computations for the project cash flow example described in Exhibit 1-1 (in Chapter 1). Notice that decision-weighted value for these cash flows is negative (−0.3) which implies that a person behaving in accordance with prospect theory and its associated parameters would choose to reject the project.

Consider the implications of using decision weights instead of actual probabilities, beginning with the case of the risk featuring a 60 percent probability of winning $4,000 and a 40 percent probability of winning $0. Using a decision weight of

EXHIBIT A1-6 Prospect Theory Analysis of Forecasted Cash Flows (in $millions) in Exhibit 1-1, with the Reference Point Being the Initial Investment of $ 3.2 Million

Future State of Economy	Managers' Probability Assessments	Cash Flow Payback (Gain/Loss)	Probabilities of Outcomes Being At Least ...	Transformed Probabilities	Decision Weights	Value	Weight–Value Product
Severe recession	2%	–$16.3	2.0%	6.2%	6.2%	–26.2	–1.6
Mild recession	1%	–$11.3	3.0%	8.1%	1.8%	–18.9	–0.4
Stagnant economy	90%	–$1.3	93.0%	81.7%	73.6%	–2.8	–2.0
Low-to-moderate growth	1%	$28.7	7.0%	13.7%	1.2%	19.2	0.2
Boom	6%	$43.7	6.0%	12.5%	2.5%	27.8	3.5
						Sum	–0.3

52 percent instead of the 60 percent actual probability to compute prospect theory's expected value leads to a change in the implicit risk premium. The sure gain of $2,400 would still be chosen. With the decision weight for the gain of $4,000 being lower (52 percent instead of 60 percent), the certainty equivalent will also lower. In this example, the certainty equivalent is below $1,100, and the corresponding risk premium is higher than when actual probabilities are used to compute expected value.

However, notice that near 0, the slope of the weighting function is much greater than 45 degrees. This implies that weights attached to the highest gains occurring with low probabilities will be much greater relative to the probabilities themselves. In particular, this will make lotteries featuring large gains with low probabilities more attractive using prospect theory weights than using the underlying probabilities. It will also make insuring against large losses that occur with low probabilities more attractive using prospect theory weights than using the underlying probabilities. That is, the steep slope of the weighting function near 0 and 1 reflect the third and fourth patterns of the fourfold pattern, namely risk seeking in the domain of gains and risk aversion in the domain of losses.

Notice that the weighting function also features the psychophysics property, in that the largest marginal increases are associated with the extremes (meaning the arguments 0 and 1 of the function).

The editing phase of prospect theory refers to decision frames. In the concurrent choice decision task, question 19 in the Questionnaire above, the choices between I and J, and then K and L, are framed within two separate "mental accounts." In contrast, Exhibit 1-4 in Chapter 1 displays the four choices as part of a single mental account. Notably, applying prospect theory valuation in the single frame would have led combination I&L to be rejected.

A key lesson to learn from the concurrent choice question is that "narrow framing" can make people vulnerable to making inferior choices about risk. This issue also arises in the way people think of one-shot risks in isolation rather than as part of a series of risks which they combine over time.

Prospect theory's three components are to be contrasted with the traditional formal framework known as expected utility theory, which features just one main component, a utility function, an example of which is displayed in Exhibit A1-3. To illustrate how expected utility theory works, consider the following example: Imagine that you face a choice about whether to stay in your current job, which involves no risk to your wealth, or take a new job which features a risk. The risk is that with probability 50 percent your future wealth will either double or be cut by x percent. Think about what the value of x would have to be so that you would be indifferent between the two options.

In expected utility theory, the critical value of x would lead the expected utility of the risk to be the same as the utility derived from the certain wealth associated with your current job. Notably, the more risk averse you are, the lower the value of x you are willing to accept. In fact, the variable $1/x - 1$ can be used to measure a concept called the "coefficient of relative risk aversion," whose value applies not just to this example but, according to expected utility theory, across all decision tasks the individual faces, regardless of framing.

[1] The full set of events in the original experiment conducted by psychologist Neil Weinstein was as follows:

Favorable events	Unfavorable events
Like postgraduation job	Having a drinking problem
Owning your own home	Attempting suicide
Starting salary > $10,000	Divorced a few years after married
Traveling to Europe	Heart attack before age 40
Starting salary > $15,000	Contracting venereal disease
Good job offer before graduation	Being fired from a job
Graduating in top third of class	Getting lung cancer
Home doubles in value in 5 years	Being sterile
Your work recognized with award	Dropping out of college
Living past 80	Having a heart attack
Your achievements in newspaper	Not finding a job for 6 months
No night in hospital for 5 years	Decayed tooth extracted
Having a mentally gifted child	Having gum problems
Statewide recognition in your profession	Having to take unattractive job
Weight constant for 10 years	Car turns out to be a lemon
In 10 years, earning > $40,000 a year	Deciding you chose wrong career
Not ill all winter	Tripping and breaking bone
Marrying someone wealthy	Being sued by someone
	Having your car stolen
	Victim of mugging
	Developing cancer
	In bed ill two or more days
	Victim of burglary
	Injured in auto accident

[2] For readers who use the metric system, note that there are 2.2 pounds in a kilo, 5,280 feet in a mile, and that 1 km corresponds to 5/8 (0.625) of a mile.

[3] The historical data for this question pertained to years 1990, 1991, and 1992.

[4] Evidence about behavioral differences across countries in respect to prospect theory can be found in: M. O. Rieger, M. Wang, and T. Hens. "Risk Preferences Around the World," *Management Science,* 61, no. 3, 2015, pp. 637–648; T. Hens, M. O. Rieger, and M. Wang, "The Impact of Culture on Loss Aversion," *Journal of Behavioral Decision Making,* 2016. The second study shows that loss aversion is positively related to individualism, power distance, and masculinity.

[5] Although prospect theory allows for different weighting functions to be used for gains and losses, this is a minor issue for the introductory discussion here, and will be ignored.